Stochastic vibrations induced by roughness under steady sliding conditions

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Abstract :

In the present paper, we study the dynamics of impacts between two rough surfaces sliding at high velocity. In our experiments, we measure simultaneously the vertical acceleration of a slider under gravity and the electric voltage across the sliding interface. The results show that the slider is always in contact with the platform at small velocities, but presents jumping dynamics at high velocities. We study the time statistics of these dynamics as a function of the sliding speed, normal load and roughness. These results will be compared with a simple bouncing-ball-like numerical model.

Keywords: friction, roughness, sliding, impact dynamic, stochastic process,

1 Introduction

The friction between two rough surfaces is characterized by a succession of shocks between surface micro-asperities. This phenomenon has been studied at low sliding velocities and it results in a dynamic vibro-impact regime causing the so-called roughness noise. The noise level depends on the surface topography, the sliding velocity and the vibrational modes. Previous studies have characterized these macroscopic relationships [1, 2]. However, their microscopic origin in terms of individual micro-impacts remains poorly understood [3]. The principal aim of the study is to provide a time-resolved statistical description of these dynamics. The measurements will be compared to simulations of a numerical model [4, 5, 6].

2 Experimental study

2.1 Set up

Consider two solids, S1 and S2, having the same topographic properties (tab.1). S1 is submitted to its own weight and is moving on S2 at constant velocity V (fig.1).
To guarantee a good temporal resolution of the micro-impacts, we put a vertical accelerometer on the moving slider. We apply a voltage V_p between the two solids and measure the electric contact voltage *U*. A force sensor measures the driving force applied by a pusher.

	S1	S2
Dimensions (mm^3)	25x25x20	300x100x20
Material	stainless steel	stainless steel
Ra (µm)	30	30

Table 1: Solid properties

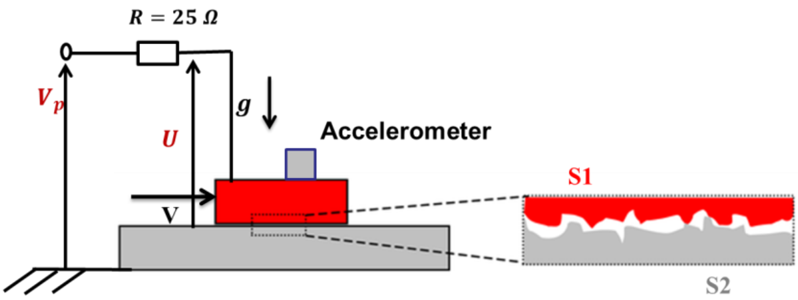

Figure 1: Sliding of dry and rough surfaces driven at constant velocity V

When there is no contact between the two solids (during jumps) the slider is in free flight, its acceleration is equal to the gravitational acceleration *g* and the contact voltage *U* is equal to the supply voltage V_p. Conversely, when an impact occurs, the acceleration is less than *g* and the electric contact voltage is very low (fig.2).

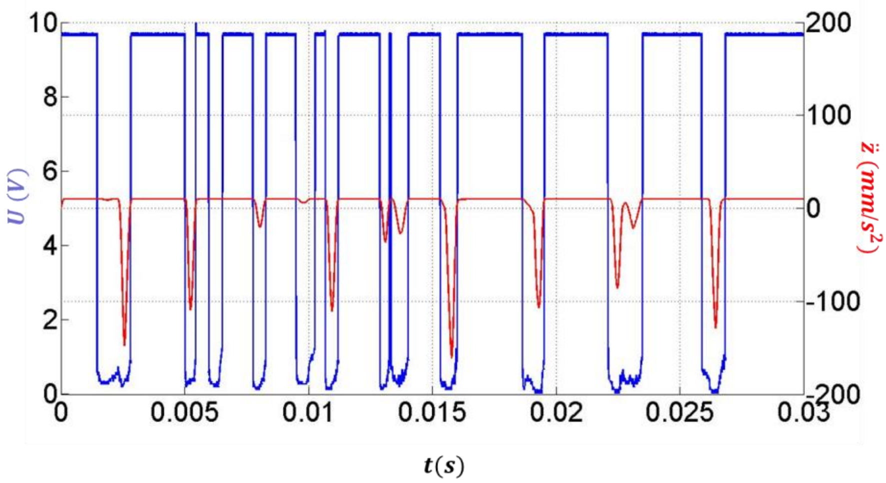

Figure 2: Example of time history measurements of the electric voltage contact *U* and the vertical acceleration.

2.2 Results

We investigated the time statistics of the jumping dynamics. As an example, in figure 3 we show the mean flight duration as a function of the driving velocity. At *V*~10mm/s, we can clearly observe a transition from a continuous contact to a jumping regime. Above the transition, the mean flight duration is found proportional to the driving velocity.

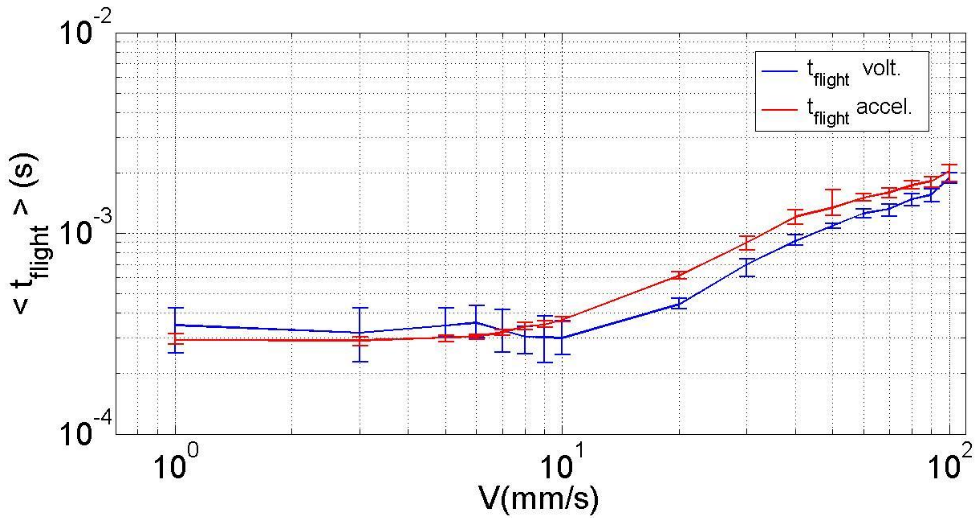

Figure 3: Mean flight duration as a function of sliding velocity.

3 Numerical model

In order to simulate the experimental results for the regime of high velocities, the sliding dry system is modelled by an adapted Bouncing Ball model [5] under stochastic excitation [6]. The model is described in figure 4. A bouncing ball of mass m impacts vertically, under the action of the gravity g, on an infinitely massive platform moving vertically with a random motion.

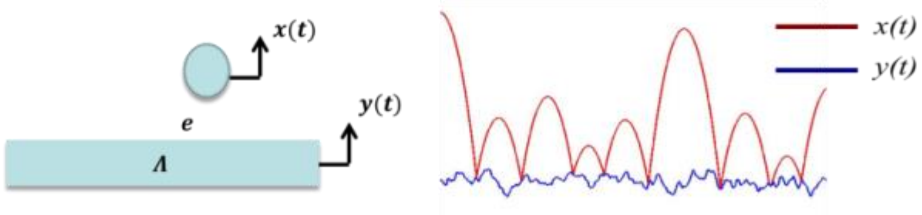

Figure 4: Bouncing Ball model

The ball's dynamics are governed by two dimensionless parameters: the coefficient of restitution e and a reduced acceleration defined by Λ. This model predicts a transition to jumping for Λ~1, which, for our system parameters, translates into V~40mm/s. It also predicts that the mean flight duration is proportional to the velocity. Both results are in good agreement with our experiments.

References

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